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WHITE GRUBS IN FOREST NURSERIES OF THE CAROLINAS

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INTRODUCTION

For many years white grubs 2/ have been recognized in many sections of the United States as serious pests of such farm products as corn, timothy, and potatoes, entire crops of which have often been completely destroyed by their destructive feeding. During recent years these insects have been the major insect pests in pine-growing nurseries of North Carolina and South Carolina, where, in many instances, solid stands of pine seedlings in localized areas in certain nurseries have been completely destroyed. In some nurseries of the Carolinas the annual loss caused by grubs has been variously estimated at from 25 to 40 percent of the original stock of pine seedlings.

It is the purpose of this circular briefly to describe these insects, the nature of their depredations, their general life history and habits, and a method for controlling infestations in forest nurseries.

DESCRIPTION OF THE INSECT

The adults, commonly called May beetles or June bugs, are more or less robust, oval-shaped beetles, ranging in length from one-half inch in the smaller species to almost a full inch in the larger ones. They vary in color from light straw to very dark brown. The elytra, or wing sheaths, which are hard shell-like covers for the membranous

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2/ *Phyllophaga* spp; order Coleoptera, family Scarabaeidae.

hind wings, are smooth and shiny in some species, but in others they are covered with short hairs. These insects become active about dusk on warm spring and summer evenings and are often seen at night flying about lights or feeding on the foliage of various plants. May beetles, which are active at night, are not to be confused with the southern green June beetles, which are active during the day, and are sometimes seen about ripe fruits, upon which they feed.

The eggs of the May beetles may be found in the soil where they are deposited by the female beetles. When first laid they are pearly white and elongate, measuring about one-tenth of an inch in length, but after a short period of incubation they become almost spherical and assume a creamy color.

The larvae, or "grubworms," that hatch from the eggs are the most commonly encountered immature form of the May beetle. They range in length from one-eighth inch when first hatched to an inch when full grown. The young larvae are almost transparent, but the older larvae are dirty cream colored. The true white grub can be distinguished from most other similar grubs by the V-shaped anal opening and by the presence of a double row of more or less conspicuous spines along the median line on the underside of the last body segment. True white grubs are found only in soil and are not known to inhabit manure heaps or decaying refuse as do the grubs of the common carrot beetle, 3/ which are often mistaken for the former. The larvae of the southern green June beetle 4/ are frequently confused with white grubs, but can be easily be distinguished from the latter by their characteristic habit of crawling on their backs when placed on the surface of the soil. The true white grub crawls in a normal position by means of its legs when placed on the soil surface.

When the grubs become mature they enter a short resting period in which they transform to pupae. The pupae are similar to the adults in general size and appearance but are yellowish to light brown in color, depending on their age. In this stage the insects are entirely quiescent and cause no damage of any kind.

LIFE HISTORY AND HABITS

In the vicinity of Georgetown, S. C., the most common species of Phyllophaga require from 2 to 3 years to complete their life cycles. However, the generations overlap so that normally there is no marked fluctuation in beetle abundance from year to year. Under natural conditions a high mortality (85 to 90 percent) occurs from the egg to the adult stage. Natural control is brought about by parasites, insect predators, birds, rodents, fungous diseases, climatic factors, and no doubt by the cannibalistic habits of the larvae.

3/ Ligyrus gibbosus (Deg.).
4/ Cotinis nitida (L.).

Oviposition, or egg laying, begins early in the spring and continues until late in the summer. The eggs are usually deposited singly in the soil at depths of from 2 to 5 inches within cavities in the center of small balls of earth.

About 3 weeks after they are laid the eggs hatch and the tiny first-instar grubs emerge and burrow through the soil, feeding on decaying vegetation and the tender roots of living plants. From 40 to 50 days later the grubs shed their skins, molting the first time, and become active, vigorous feeders. From 6 to 8 weeks after the first molt many of the larvae shed their skins the second and last time to become third-instar grubs, in which stage they spend the first winter. Others, however, overwinter in the second instar and molt the following spring or summer.

During the winter the larvae are relatively inactive, but they resume their feeding early in the second spring and cause considerable damage to the young seedlings.

For the species that appear as adults early in the spring it has been found that during mid-August of the second summer about 75 percent of the larvae cease feeding and dig deep into the soil, where they make oval-shaped earthen cells in which the pupal stage is passed. About 2 weeks later the pupae transform to adults, which remain in the soil until spring. The remaining 25 percent continue to feed throughout the second summer and pass the second winter as third-instar larvae. During the third summer they pupate, pass the third winter in the adult stage, and emerge from the soil during the fourth spring. Thus about 75 percent of a single generation may complete the life cycle in 2 full years and 25 percent in 3 full years.

Species that make their first appearance as adults in midsummer probably vary from the above in that they pass the third winter as third-instar grubs, which pupate in the spring and emerge from the soil the following summer.

In the coastal plains of the Carolinas the larvae show a slight tendency to burrow deeper into the soil during the winter, but many grubs can be found near the surface throughout the year. During the first year of development the larvae may migrate laterally as much as 5 to 7 feet through the soil, while second-year grubs are perhaps slightly more active and may migrate as much as 6 to 9 feet. Inasmuch as the total distance of migration of the larvae ranges between 11 and 16 feet, there is little likelihood of a nursery becoming infested by grubs migrating into the seedbeds from adjoining infested areas.

The adults are active from early in the spring until late in the fall. Some species begin to emerge during the first week of April and continue to appear until midsummer, whereas other species make their first appearance in June or July and continue their activity until late in September. At dusk on warm evenings they emerge

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from the soil, fly about for a few minutes, and alight on the foliage of plants, where they mate and feed until dawn, at which time they leave the foliage and return to the ground. Some species, especially those that appear in the spring when early morning temperatures are low, drop directly to the ground underneath the host plant and burrow into the soil. Other species, which emerge from the soil later in the summer when morning temperatures are relatively high, glide or fly from the host plants and alight on the ground some distance away. The majority usually land within 100 feet of the host plant, but some individuals travel 300 feet or more before alighting. The beetles apparently do not select any particular site on which to land, alighting indiscriminately in woods, fallow areas, and seedbeds, where the female beetles deposit their eggs to begin another generation.

Twenty-three species of Phyllophaga have been collected near forest nurseries of the Carolinas. Fortunately only three species 5/ were found associated with forest nurseries in sufficient numbers to be of economic importance. It should be kept in mind, however, that all species of May beetles are probably potential nursery pests.

PLANTS DAMAGED

White grubs injure a wide variety of plants, including corn, timothy, potatoes, wheat, strawberries, grass in lawns, and tree seedlings, particularly coniferous nursery stock. Slight damage to ash and tulip poplar seedlings has been observed, but black locust in heavily infested seedbeds was apparently uninjured. In southeastern forest nurseries pine seedlings bear the brunt of the ravages of these pests. Longleaf pine, because of the nature of its root system, is probably capable of withstanding greater grub injury than loblolly, shortleaf, or slash pine, but white grubs attack all these species without discrimination.

Unlike the grubs, the adults of the different species of Phyllophaga differ in their host preferences. Some species feed almost exclusively on pines, while others prefer oaks, and still others feed indiscriminately on a wide variety of host plants. The trees on which May beetles most frequently feed in the Carolinas are pines and oaks; but they were collected from such diverse hosts as hickory, black gum, persimmon, sweetgum, black locust, chestnut, willow, elm, witch-hazel, Deutzia, blackberry, pecan, alder, gallberry, and running rose.

TYPES OF INJURY

In the Carolinas the chief damage is caused by the feeding of the grubs on the plant roots. The adults seldom become sufficiently numerous to cause serious damage to the foliage of the plants on which they feed, as they do in certain other parts of the country. Injury to pine seedlings is caused by the feeding of the larvae on the lateral

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5/ Phyllophaga prununculina (Burm.), P. luctuosa Horn, and P. forsteri Burm.

and tap roots of the plants. If continued long enough, this results in the death of the seedlings. Grub-damaged plants can be detected by the abnormal appearance of the needles or by exerting a gentle pull on them. An injured plant can be easily pulled up, whereas a healthy plant will remain firm. Severely injured plants are usually sickly or dying in appearance.

Four general degrees of damage are recognizable (fig. 1), but variations from these types are to be expected. (1) Injury may be confined almost entirely to the lateral roots (fig. 1, B). This type of injury is most prevalent in mid summer and is usually the work of first-year larvae in the early stages of development. Plants injured in this manner may survive if no further feeding occurs and the soil is sufficiently moist. (2) Continued larval feeding may result in the destruction of the lateral roots and a portion of the tap root (fig. 1, C). (3) The lateral roots and the bark and cambium of the tap root may be eaten away (fig. 1, D). Seedlings damaged to the extent described in the last two classes have no commercial value, although they may survive in the seedbeds if no further feeding takes place and the soil remains moist. (4) The tap root may be severed just under the surface of the ground (fig. 1, E), in which case the seedling invariably dies. The last three types of damage are usually caused by the feeding of second- or third-instar grubs and may be found at any time from early in the spring until late in the fall, although they are most prevalent from midsummer to late fall when first-year grubs are most active. Root injuries of the types illustrated are usually accompanied by a wilting of the tops and browning of the needles. However, if the grub infestation is particularly severe during cool, moist periods, all four degrees of damage may occur unaccompanied by immediate changes in top appearance.

PERIOD OF HEAVIEST DAMAGE

As mentioned above, grub damage in southeastern nurseries may occur at any time during the growing season, from early in the spring until late in the fall; but most severe injury occurs from mid-August to late in October. This damage is the result of feeding by first-year grubs. Therefore, from the standpoint of remedial control, most concern must be given to the current season's brood of grubs which hatch from eggs laid after the seedbeds are planted.

CONTROL MEASURES

Selecting the Nursery Site

As a means toward preventing damage caused by white grubs, soil that is free from these insects should be selected for nursery sites. Certain localized areas may be heavily infested, whereas other areas which are equally well adapted to the production of seedlings are almost entirely free from grubs. Much damage can be prevented if soils that are already infested are avoided.

Whether or not a prospective nursery site is infested with grubs can be determined by searching for the adults on the foliage of plants growing on the area. Such inspections should be made on warm summer nights at intervals over a period of a few weeks. The presence of an abundance of beetles indicates future trouble from grubs.

An estimate of grub population can also be obtained by screening soil samples to recover larvae. Taking 1-cubic foot samples of soil at regular intervals of 40 feet proved to be a fair index to grub population in a South Carolina nursery.

Injecting Carbon Disulfide into the Soil

Of the numerous methods tested, the injection of carbon disulfide into the soil at the rate of 1 pint per 100 square feet of soil surface appears to be the best available means of control for white grubs in forest nurseries. Although this chemical may not eradicate all the larvae, when used judiciously it is an effective control measure and causes negliglble injury to pine seedlings. Under most nursery conditions excellent control of larvae may be expected in the upper 6 inches of soil where most of the grubs are found during the period of severest injury. The depth of penetration of the chemical depends somewhat on the nature of the soil, for the highest grub mortality is obtained in sandy or sandy loam soils of a loose, porous nature.

In applying the chemical it is important to avoid treatment of soils that are too wet (above 15 percent in moisture content), as this condition results in severe chemical burning of the pine seedlings. Minimum plant injury is incurred when treatments are made in soils that are in a suitable condition for cultivation, i.e., moist and friable. The chemical remains in the soil at least 1 hour after it is applied, therefore the treated areas should not be watered within 1 hour after treatment, as this will cause chemical injury to the seedlings.

To obtain maximum control of the grubs with minimum chemical injury to the seedlings, the following conditions must be complied with:

(1) The soil, as just stated, should be moist and friable (suitable for cultivation), and it should not be watered within 1 hour after treatment. The carbon disulfide should not be injected into the soil immediately before or after rains, as treatment under such conditions, when the ground is wet, results in severe burning of the plants.

(2) The temperature throughout the entire upper 6 inches of soil must be 78° F. or above.

(3) The chemical should be injected into holes in the ground 3 to 4 inches deep, spaced 6 by 6 inches apart, at the rate of 1.2 cc. per hole. Immediately after the chemical has been injected, the holes should be filled with soil and the soil firmly packed.

Carbon disulfide is inflammable and should be handled with the same care with which gasoline is handled.

Carbon disulfide may be injected into the soil with an ordinary hypodermic syringe without the needle, or with an injector for forcing liquids into the soil. 6/ This injector greatly facilitates treatment and prevents loss of the chemical by evaporation.

This method of control can be used for treating local "spot" infestations, or for general treatments of entire seedbeds. In making treatments where only a few plants have been damaged, the chemical should be applied to the area immediately surrounding the infested area as well as to the known infested area, in order to kill migrating larvae. General treatments should be made when grub-injured plants are found throughout the seedbeds. The extent of damage can be determined by the appearance of the plants, and by gently pulling seedlings here and there in the seedbed as previously described.

Cost of Treatment

The cost of treatment depends to a large extent on the cost of labor. Carbon disulfide can be purchased wholesale at a cost of approximately $1 per gallon. At the rate of 1 pint per 100 square feet, the cost of the chemical alone is 12½ cents per 100 square feet of seedbed. Assuming that 1 square foot of seedbed will yield 30 merchantable seedlings, the cost of treatment is slightly over 4 cents per 1,000 plants, exclusive of labor.

Mechanical Barriers

Plots of very valuable plants may be protected from white grub infestations by surrounding them underground to a depth of 18 inches with 18-mesh wire screen and providing covers of ¼-inch-measure hardware cloth for the tops of the seedbeds. This method of control, however, may be too expensive and impractical for general nursery practice.

SUMMARY

In southeastern forest nurseries the feeding of white grubs (Phyllophaga spp.) on the roots of young tree seedlings results in a heavy loss in the annual production. The southern pines, notably longleaf, shortleaf, loblolly, and slash pines, suffer the most severe

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6/ Eaton, C. B. An injector for forcing liquids into the soil. U. S. Dept. Agr., Bur Ent. and Plant Quar., ET-127 (multigraphed). 1938.

injury, although attacks on various hardwoods have been noted. Several degrees of root injury, associated with grubs of various ages, are recognizable.

The species most commonly found in this section have a life cycle of from 2 to 3 years, the greater part of which is spent in the grub stage. Both first-year and second-year larvae cause injury, but the former, which hatch from eggs laid in the ground after the seedbeds have been planted, cause the most severe damage late in the summer. Early-season damage is usually caused by second year grubs. The larvae are more or less inactive during the winter months and show a slight tendency to seek the lower levels in the soil as the temperature decreases.

Carbon disulfide injected into the soil at the rate of 1 pint per 100 square feet seems to be the best available means of control for these insects. Protection may be secured at a cost of slightly over 4 cents per 1,000 plants, exclusive of the cost of labor for the application of the chemical.

Figure 1.-- Root injuries on pine seedlings as a result of feeding by Phyllophaga larvae: A, Healthy root system; B, light damage (ends of laterals and tap root cut); C, severe damage (all lateral roots cut); D, severe damage (lateral roots cut and cambium stripped from tap root); E, severe damage (tap root cut just beneath the surface).

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